



Institute For Thermal Processing Specialists

PROTOCOL FOR CONDUCTING TEMPERATURE DISTRIBUTION STUDIES IN WATER-CASCADE AND WATER-SPRAY RETORTS OPERATED IN A STILL MODE, INCLUDING AGITATING SYSTEMS OPERATED IN THE STILL MODE

Various methods and equipment may be employed to achieve and verify the temperature distribution conditions in a retort that ensures all areas of the retort receive the scheduled process. **The following recommendations are to be considered voluntary guidelines.** While this does not preclude the application of other methods and equipment for determining whether adequate temperature distribution is achieved in a retort to ensure delivery of the scheduled process, these guidelines have been developed by consensus of the Institute For Thermal Processing Specialists and should be given serious consideration for adoption as methodology by individuals performing temperature distribution studies on still water-cascade and water spray retorts.

For purposes of this document, a water *cascade* retort is defined as one where a small amount of process water is drawn from the bottom of the retort by a high capacity pump and distributed through metal plate(s) or manifold(s) in the top of the retort. This process water cascades down over the retort crates, cages or racks in a rainwater or “shower” fashion, passing over the product containers on the way back to the bottom of the retort where it is recirculated through the heating and distribution system. Processing water may be heated using one or more direct or indirect heating methods including heat exchangers, direct steam injection, or via steam distribution pipes or spreaders.

A water *spray* retort is defined as one where a controlled amount of process water is drawn from the bottom of the retort by a high capacity pump and distributed through spray nozzles located along the top and sides of the retort. This process water is sprayed over the retort crates, cages or racks in a high-pressure “mist” fashion passing over the product containers on the way back to the bottom of the retort where it is re-circulated through the heating and distribution system. Processing water may be heated using one or more direct or indirect heating methods including heat exchangers, direct steam injection, or steam distribution pipes or spreaders.

1. PROCESSING EQUIPMENT SURVEY

It is important to establish proper documentation during the survey of the processing room, so that a valid evaluation can be made in the process of selecting the test retort(s) (see Note 1). This survey should include examination of the following:

1.1 Steam supply to the retorts

- 1.1.1 Boiler capacity (horsepower or Btu rating), pressure, and method of firing (gas, oil, coal or dual capacity).
- 1.1.2 Header pressure. It is important to determine that adequate steam pressure and volume is available for the retorting system. This part of the survey should be performed during both peak use and off load hours.
- 1.1.3 Pipe size and length, valve size and types, from the main steam line to the test retort(s).

1.1.4 Size of all connecting steam pipes to the main line, noting all equipment using steam (e.g., blanchers, exhaust boxes, etc.).

1.2 Retort room

Type and size of each retort; manufacturer and, if known, serial number and date of manufacture.

1.3 Air supply to the retorts

1.3.1 Compressor type, capacity and operating pressure.

1.3.2 Type and size of filter, dryer and tank.

1.3.3 Line size, pressure, filters and dryers for instrument air.

1.3.4 Process air header line size(s), pressure and pressure regulation, if used.

1.4 Water supply to the retorts

1.4.1 Process water supply source, temperature, pressure and controls, if any.

1.4.2 Cooling water supply source, temperature, and controls, if any.

1.5 Overflow/purge (air removal)

Valve type and size, pipe size and connections to drain headers or channels.

1.6 Drain

Valve type and size, pipe size and length; also note if check valves are used.

1.7 Retort loading considerations

1.7.1 Container information: material, size and dimensions; orientation for processing (vertical or horizontal); and loading configuration (layered, nested, compartmented, or offset). Relative to the orientation of containers during processing, there may be some processors who wish to change the basket, and therefore the container, orientation prior to starting the process cycle. For example, a processor may wish to turn the baskets a quarter turn, moving the containers from a vertical to horizontal orientation. Because this may significantly change the flow pattern of the process water, the processing specialist needs to determine from the processor every container orientation which might be used in processing and then test the “worst-case” situation.

1.7.2 Type of product heating (convection, conduction, or broken).

1.7.3 Maximum number of containers per layer; maximum number of layers per basket; maximum number of crates, baskets or racks per retort.

1.7.3.1 Partial load arrangement.

1.7.3.2 Water displacement requirements (ballast).

1.7.3.3 Crate, basket or rack dimensions.

1.7.4 Hole size, configuration and spacing in the base plate and sides of crates, baskets or racks and in separator sheets used in same. Percent open area in layer dividers.

1.7.5 Distance between crates, baskets or racks, where applicable.

1.7.6 Orientation of the crates, baskets or racks in the retort during come-up and processing.

Note 1. While retort room surveys are not a part of temperature distribution per se, they are important in identifying retorts to be tested, documenting the conditions of the temperature distribution study, as well as helping plant management realize that projects outside the retort room may have an effect on retort operations.

2. SELECTION OF THE TEST RETORT (S)

In general, all of the information taken in the retort room survey should be used to select the retort(s) that will be tested for temperature distribution. The retort(s) selected should represent the one(s) identified as having the greatest potential for diminished delivery of the scheduled process. Factors that may help identify the test retort(s) include retort position (at the beginning or end of a line of retorts), container configuration, divider style, and partial loads. New retorts can be

presumed to require temperature distribution studies. Similarly, retorts that have undergone extensive repair or redesign can be expected to require temperature distribution studies. It would not be unusual for all retorts in a retort room to be tested on a regular basis because of the mechanical nature in which temperature distribution is established, especially in horizontal retorts. The replacement or normal wear of components associated with establishing acceptable temperature distribution also warrant consideration for performing temperature distribution studies. These components may include: water circulating pumps, valves and pipes associated with steam/water flow, water manifolds, water sprays, air orifices, and overflow/pressure regulating valves.

Note: For some systems it has been reported that retort temperature distribution varies with individual installations of identical equipment at the same location. Consideration should be given to performing temperature distribution in each individual retort system to document variation in individual systems

3. TEST RETORT DOCUMENTATION

Provide a diagram and description, including comments on condition, for the following, if applicable.

3.1 Retort shell Physical dimensions of retort and capacity (number of crates) retort is able to hold.
Secure, if possible, the retort manufacturer's or factory's blueprints of the retort and all attendant piping.

3.2 Steam supply from main line to the retort

Pipe size, valve size, valve type, and pressure regulator(s).

3.3 Heating the processing water

3.3.1 Type and specification of the steam distribution system including configuration, steam flow piping, size, number, and location of steam injection perforations, if applicable.

3.3.2 Steam injection chamber, if applicable.

3.3.3 Describe the heat exchanger used to heat and cool the processing water including type (e.g. tube-in-tube, plate, etc.). Describe the heating medium (e.g. steam, hot water, etc.) and temperature. Describe the cooling medium (e.g. re-circulated refrigerated water, ambient well water, etc.).

3.4 Temperature control sensing device

Type and location of the temperature-control device. Describe location of control sensor in relation to the TMD sensor and to the steam distributor. Note if the temperature control sensor is located directly in the cascading or spray water.

3.5 Type of instrument well(s)

Size, shape and location of well(s) used to locate sensors (list sensors).

3.6 Pressure Sensor

Note type, range and location of pressure sensors and gauges.

3.8 Reference temperature-measuring device (TMD)

3.8.1 Mercury-in-glass (MIG) thermometer location, temperature range and increments; length of scale; date of calibration, and length of insertion; i.e. the length of the sensing bulb that is inside either the retort shell or instrument well.

3.8.2 Electronic TMD type (RTD, thermocouple, thermistor, etc.), range, response time, location and length of insertion.

3.8.2 Note if the temperature-measuring device is located directly in the water cascade or spray.

3.9 Temperature controller or recorder/controller

3.9.1 Process timing (automatic or manual).

3.9.2 If microprocessor-controlled, describe tuning parameter values (PID) used for come-up and thermal process phases, and the amount of offset applied to the control variable, if any.

3.9.3 If computer-controlled, describe the name of the system and the program used to control the process, including the revision number or program date.

3.94. If cam-controlled, describe cutout profile, to include any overshoot incorporated.

3.10 Air purge (if applicable). Air purge in these systems is normally part of the overpressure control system.

Valve types, sizes and location with piping connections, if applicable.

3.11 Drain

Size, type, location, and piping connections.

3.12 Water circulation

3.12.1 Processing water: sizes, types, and location of valves and piping, if applicable.

3.12.2 Method of water circulation.

3.12.2.1 Pump specifications, including rated output at operating conditions (e.g., gpm), if applicable, rpm, pipe diameter for pump inlet and outlet and horsepower rating.

3.12.2.2 Air flow: orifice size, pressure setting and flow rate (during test).

3.12.2.3 Flow sensor (water): type and location, if applicable.

3.12.2.4 Pressure and/or flow switches: type, location, and trip point setting.

3.13 Water Distribution Manifold(s) or Plate(s) (Water Cascade Retorts)

3.13.1 Location of water inlet pipe to manifold (e.g. top/center of retort shell; top/rear of retort shell).

3.13.2 Dimensions of manifold and material of which constructed.

3.13.3 Number, size and location (hole pattern) of holes in manifold; the percent open area of the holes should be calculated.

3.14 Water Distribution Pipes (Water Spray Retorts)

3.14.1 Location of entrance of water inlet pipe to retort shell.

3.14.2 Location of water distribution pipes in relation to circumference of interior of retort.

3.14.3 Length of pipes; do they extend length of retort?

3.14.4 Number, size and location of holes in pipes.

3.14.5 If connected to nozzles describe nozzle type. If nozzles are fixed or capable of oscillation. Describe if nozzles restrict diameter of hole openings.

3.14.6 Describe water flow rate at nozzle (s) (e.g. liters per min, gallon per minute etc.)

3.15 Process water retention channel or trough in bottom of retort.

3.14.1 Note if and how process water is retained for cooling or re-use.

3.14.2 Length, width and depth of water channel or trough.

3.14.3 Amount of water (liters or gallons) at start of process; and how it is controlled and measured

3.14.4 If applicable, location of steam distributors or spreaders in relation to channel or trough.

3.16 Overpressure

Location and size of pipes and valves and method of control.

3.17 Other equipment

Other control or functional equipment installed that might affect the temperature distribution.

4. TEST EQUIPMENT

4.1 Data acquisition system

The system should be equipped with sufficient channels to adequately monitor and record temperature/pressure within the process delivery system. Manual recording of data may be used, if a sufficient sampling frequency can be maintained.

4.2 Temperature measuring devices (TMDs)

Use thermocouples or other devices of sufficient accuracy in sufficient quantity to adequately monitor the process water temperatures within the retort. Because of design differences in many of these systems (e.g. location of the process water intake to the retort) causing variability in location of the slowest heating (coldest) zone in the slowest heating basket/rack/crate, it is recommended that temperature distribution be run in two (2) phases. (1) Determine the slowest heating layer in each basket. (2) Confirm the slowest heating zone in the slowest heating basket. See 6.1.4 for recommendations on the number of TMD's to use for each phase.

4.3 Pressure indicating device(s)

Operations' gauges and electronic indicators may be used to monitor pressures associated with the retort operation during the test, but they should be of recent calibration. Separate test devices may be used if desired. Typical measurements would include retort vessel pressure, steam line pressure, sparge air line pressure and cooling water line pressure.

4.4 Reference TMD

Include if the test retort TMD is not going to be used.

4.5 Packing gland (stuffing box)

Rubber soft enough to provide a tight seal without overtightening and damaging the leads should be used for entry of lead wires into the retort, if applicable.

4.6 Flow meters

4.6.1 Should be used to measure flow of process water during come-up and heating. .

4.6.2 May be used to measure volume of airflow in water spray systems using air for overpressure.

5. STANDARDIZATION OF TEST EQUIPMENT

5.1 Retort thermometer/TMD

The retort MIG thermometer/TMD must conform to applicable regulations and shall have been checked for accuracy against a certified TMD within the past year, preferably more recently. Indicate the date the Reference (retort or other) TMD was last checked for accuracy.

5.2 Temperature measurement system

5.2.1 Prior to conducting the actual temperature distribution study, standardization or calibration of the test equipment should be performed in the test retort (as defined in Section 2) with all leads, extensions and connections assembled as they will be used under actual test conditions. The use of wired sensors normally requires a method of signal grounding. Follow the recommendations of the datalogging equipment manufacturer or consult with an instrument professional if you are unsure about the correct grounding technique to use.

5.2.2 One acceptable method of calibration is to bundle all TMDs and locate them in close proximity to the known accurate MIG thermometer/ reference TMD, taking care not to inhibit the water flow past the reference probe.

5.2.3 Bring the retort up to the same temperature and pressure as for the distribution test and allow temperatures in the vessel to equilibrate.

5.2.4 Check the accuracy of the TMDs against the known accurate reference instrument. Any single TMD should agree to within 0.5°F (0.3°C) of the reference TMD/MIG thermometer. The range for all TMDs should be not more than 1°F (0.6°C). Any TMD which deviates from the above criteria should not be used until corrective action is taken that results in the TMD meeting the criteria. The TMD in closest agreement with the reference TMD should be attached to the reference probe and becomes the secondary reference TMD for data evaluation.

5.2.5 To meet the calibration criteria above, and to ensure the accuracy of the test results, consideration should be given to minimizing errors inherent in any component of the temperature measuring system. For example, the use of special limits of error, premium grade thermocouple wire from the same spool to make thermocouple leads, or 3 or 4 wire high accuracy RTDs can help to reduce intrinsic error.

5.2.6 The use of less restrictive criteria is acceptable, but may affect the control-offset amount needed in the operation of the retort.

6. PLACEMENT OF THE TEMPERATURE, PRESSURE AND FLOW MEASURING DEVICES

6.1 Location of the TMDs in the retort

TMDs should be placed in the following locations:

6.1.1 Attached or in close proximity to the reference TMD probe.

6.1.2 Attached or in close proximity to the temperature controller probe, unless the reference TMD and the controller probe are located together.

6.1.3 Located in two containers filled with test medium for the purpose of determining initial product temperatures (If there are data on hand that correlate temperatures measured by free leads to a specific initial product temperature - prior to making the TD study - such correlation may be used in lieu of measuring actual initial temperature.)

6.1.4 A minimum of five (5) leads per basket/crate/rack should be used; each located in different layers or otherwise separated in each basket/crate/rack in the initial phase of the temperature distribution study, made to determine the slowest heating (coldest) layer in each basket/crate/rack. Leads should be placed so those measuring junctions are not in direct contact with containers or other internal surfaces. Once the slowest heating (coldest) layer of each basket/crate/rack has been determined, at least four (4) leads should be located in this layer in the second phase of the study to confirm the slowest heating (coldest) spot (s) in the retort.

In a re-validation study, where no changes have been made to the equipment and previous studies have indicated consistency of cold spot location, the second phase study using four (4) TMD's per basket/crate/rack may be sufficient.

6.1.5 Depending on the processing system, it may be necessary to place additional TMDs at other locations in the retort to adequately monitor cold spot(s).

Note: Cold spots are generally those areas of the retort, which are the last areas in the retort to reach a minimum processing temperature during come-up.

6.2 Location of pressure sensor(s)

At least one pressure sensor should be located in the retort shell. If the operational pressure sensor has been recently calibrated, it can be used in place of a test device. Pressure gauges should also be used to monitor line pressures of steam, air and cooling water during a test.

6.3 Location of flow meter(s)

6.3.1 A calibrated flow meter (or alternate method) should be located in a manner to provide an accurate record of the water circulation flow during the process cycle on systems using circulation pumps.

Note: The use of differential pressure across a circulation pump (used in some water cascade/water spray systems for production control) may not provide a complete indication of water flow in a system.

7. PREPARING RETORT WITH CONTAINERS

7.1 Container size

Select the container size processed in the retorts that will yield the worst-case condition for the commercial operation from a temperature distribution standpoint. In many cases this will be the smallest container in use. In some cases, each container size, type, configuration and orientation will have to be tested.

Note: Since temperature distribution may vary widely with these systems depending on container and type, it may be necessary during the initial temperature distribution testing to test every container and type until such time as it can be

demonstrated that one particular container size or type (e.g. metal can, glass jar, retort pouch, etc.) yields worst-case results.

7.2 Container contents

Containers may be filled with water, or the fastest heating product, for studying retorts that process convection heating products. For conduction heating products, the containers should be filled with product, a starch solution, or other material that simulates the product. Water may also be used, but the come-up times will be somewhat longer than will occur with product.

7.3 Container placement

Containers are placed in the crates, etc. in a manner that is equivalent to the worst-case situation as seen in the commercial operation. This may need to be determined through additional testing. If separator or divider sheets are used between the layers of containers, then the dividers with the smallest percent open area should be used for the tests. If additional dividers are used on either the top or the bottom of the container load, this procedure must be duplicated for the test.

Note: Be alert in designing the test for the use of more than one divider sheet either on top or bottom of the crate, or between layers. If no divider sheets are used, the ability of the containers to “nest” or move must be taken into consideration.

7.4 Operating procedures

Normal commercial operating procedures should be followed, e.g., if the crates, etc. are rotated during come-up or repositioned for thermal processing.

8. THE TEMPERATURE DISTRIBUTION TEST

8.1 Set up

8.1.1 Verify the retort survey.

8.1.2 Establish the initial product temperature. The initial product temperature for a test run is the warmest of the temperatures measured in an instrumented container at the start of the test. The range of initial temperatures to be encountered during regular commercial operation should be taken into account in establishing temperature distribution. If instrumented containers are not used, there should be some other means of determining the initial temperature. The initial temperature measured should be considered in the context of retort shell, crate, and/or process water temperatures, which may be lower or higher than the measured initial temperature, and could effect the come-up time required to bring the retort to processing temperature.

8.1.2 *It is absolutely essential* to check the water nozzles, distribution pipes, manifolds and other water distribution orifices prior to making the first temperature distribution (or calibration) run to ensure all holes are cleared and free of debris. Should any be found to be blocked – and (as is likely) the retorts have been used to process product – it will be necessary to study the “blocked hole” condition first, prior to clearing all blockages to make a “clean” run.

8.2 Data collection points

The following are critical and should be monitored and recorded during the test:

8.2.1 Temperature controller set point, including if there is an overshoot set point for come-up and a lower set point for processing.

8.2.2 Initial temperature.

8.2.3 Time steam on or “0” time.

8.2.4 Temperature of process water supply, if preheated.

8.2.5 Flow rate of water as determined by flow meter or other acceptable means.

8.2.6 Time when the reference TMD/MIG achieves the process set point temperature.

8.2.8 Time when the end of come-up, start of thermal processing phase has been achieved, as indicated by either the phase change in a control program or the achievement of scheduled process temperature at both the reference TMD/MIG and the recorder/controller.

8.2.9 MIG/ reference TMD readings at sufficient intervals, including the point in time it reaches the process temperature setpoint.

8.2.10 Air flow in scfm or liters per minute (if applicable and available).

8.2.11 Line steam pressure at the time of the test and before, during, and after come-up, if possible.

8.2.12 Line air pressure at the time of the test and before, during, and after come-up, if possible.

8.2.13 Retort overpressure, throughout test cycle at sufficient intervals or on continuous chart.

8.2.14 Time of end of thermal process, start of cool.

8.2.15 Actual crate/ container orientation in the retort.

8.3 Miscellaneous observations

8.3.1 Number of other retorts in operation at the time of the study.

8.3.2 Other retorts entering come-up during the study.

8.3.3 Temperature of retort cooling water, especially if general method or modeling calculations are performed as part of the temperature distribution study.

8.3.4 Numbers and descriptions of other equipment using steam (e.g. blanchers) at the time of the test and before, during and after come-up.

9. CONDUCTING THE TEST

9.1 Datalogger

The datalogger should record the temperature of each TMD in the crates or baskets, at sufficient intervals, not to exceed one minute, throughout the length of the study. The datalogger record is part of the permanent records for the temperature distribution study.

9.2 Other critical data collection point logging frequencies

Critical points should be recorded at intervals of sufficient frequency to describe and verify retort-operating parameters during the test. These recordings are part of the permanent test record and should include the temperature recording chart, the pressure readings or chart, flow rate records, MIG thermometer/reference TMD readings, and other data gathered that have been identified as critical data collection points.

9.3 Study time duration

Testing time depends upon:

9.3.1 The precision of temperature and pressure control and whether the retort has stabilized and a definite temperature profile has been established.

9.3.2 Normal production process times, except that test should be extended to include a minimum of fifteen minutes at process temperature.

9.3.3 Cooling phase temperatures being recorded until test container temperatures have fallen below 200°F (94°C). This is especially important if cooling lethality is based on actual cooling profiles in developing scheduled processes.

9.4 Retort test temperature

Temperature distribution studies should be run at the maximum retort temperature to be used for processing. For example, one should not run temperature distribution at 121°C (250°F) if the product is processed at 130°C (266°F). Generally, temperature distribution studies should not be run any higher or lower than 2.8°C (5°F) from the temperature at which the product will be processed. If the retort is operated at more than one temperature range [e.g. 121°C (250°F) & 130°C (266°F)] temperature distribution studies should be performed at each of the processing temperatures.

9.5 Replication

At a minimum, duplicate temperature distribution studies should be performed for each situation (e.g. container size, container type, operating temperature, crate/racking system, etc) with uniform/comparable results obtained from each test. Duplicate test should be performed for both the initial (coldest layer in each basket) and confirmatory (coldest spot in the retort) phases of the study (see 4.2 and 6.14)

9.6 Post-test inspection

The condition of the measuring sensors, the test containers, and other attributes of the retort load should be examined after the completion of the test to determine if the test results may have been affected by movement or other changes to the desired test setup.

10. MAINTENANCE

10.1 Maintenance of the water circulation system for a water cascade or water spray retort is critical. Particular attention must be paid to the openings in the water distribution manifold for water cascade retorts; and the spray nozzles for the water spray retorts. These openings, depending on the hardness of the process water, can become clogged with rust and scale, resulting in process “dead zones” within the crates or baskets.

In addition, replacement of major parts of the water circulation system (manifold, pump, spray nozzles, valves, etc.) or the changing of pipe sizes in the water distribution system must be confirmed by new temperature distribution testing to ensure the replacement equipment performs the same as that previously tested.



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Part of the mandate of IFTPS Technical Committees is to develop protocols to be used as guides for carrying out the work of thermal processing specialists. This protocol was prepared by the Committee on Temperature Distribution and reviewed extensively by members of the Institute. The protocol was approved for publication in February, 2005 by the IFTPS Board of Directors.

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